DEVELOPING A PRONUNCIATION COMPUTER PROGRAM FOR THE ACQUISITION OF ENGLISH PHONEMES AND WORD STRESS

JHAO-NAN HONG
National Yunlin University of Science and Technology, Taiwan
m10341012@yuntech.org.tw

JAMES H. YANG
National Yunlin University of Science and Technology, Taiwan
jamesyang1118@gmail.com

Abstract
This study devised a pronunciation computer program to examine whether mobile-assisted language learning (MALL) could facilitate college students' acquisition of English phonemes and word stress. Thirty-eight participants enrolled in the remedial English class offered at the language center of a national technological university in central Taiwan. Before the class, they were asked to read a word list. In the following six weeks, they were taught to distinguish and articulate English phonemes and to predict word stress locations using the designed computer program. They were also instructed to review the learning materials using the smart-phone version of the devised program. After the teaching session, each participant was asked again to read the same word list and fill out an assessment questionnaire. The sound analyses show that their readings of English minimal pairs and word stress placement were more accurate than their performances before the instruction. Their responses to the questionnaire indicate that both the given instruction and the designed computer program were satisfactory. In the open-ended questions, some of them said that they have built up a better understanding of phonemes and word stress, and that they would try to predict polysyllabic word stress when reading English articles. The present findings can be further applied to research on MALL-based English pronunciation acquisition.

Keywords: MALL, phonemes, word stress

1. Introduction

Pronunciation, a fundamental element of foreign language learning, plays a crucial role in communicative settings (Akyol, 2013; Hismanoglu & Hismanoglu, 2010). When learning a new foreign language, people usually start by learning the pronunciation of that particular language. The knowledge of phonics is usually taught before the learners acquire the grammar of the language in language learning. However, pronunciation is considered the key part in a conversation when two people communicate with each other because the accuracy of one's pronunciation directly affects the other's intelligibility. For instance,

Chavangklang (2013) found that misunderstanding may occur if students fail to pronounce English words correctly. By contrast, Hahn's (2004) research on primary stress and intelligibility indicates that native speakers of English make less effort to comprehend nonnative speakers' discourse with correct primary stress. Thus, pronunciation accuracy helps listeners understand the speech made by nonnative speakers of English.

Regrettably, pronunciation teaching is often neglected in English classrooms around the world. Little emphasis on pronunciation has led to students being equipped with scarce phonetic knowledge with regard to "segmental and supra-segmental aspects of English pronunciation" (Hismanoglu & Hismanoglu, 2010, p. 984). It has been found that many English teachers focus only on grammar and vocabulary (Chavangklang, 2013; Hismanoglu & Hismanoglu, 2010). Moreover, it is evident that language learners with a large size of vocabulary and excellent command of English grammar still have difficulty with their pronunciation (Celce-Murcia, Brinton & Goodwin, 1996). In view of the importance of intelligible pronunciation, English teaching cannot only be limited to the acquisition of grammar (Gilakjani, 2012).

Although some studies have identified the factors affecting English pronunciation of Taiwanese learners (Chang & Jian, 2008; Chung, 2006; Ou, 2010; Yang, 2012), very few studies have developed instructional programs for pronunciation teaching and learning. For this reason, a computer program was developed in this study for pronunciation instruction which aims to improve under-achievers' pronunciation, with the focus on phonemes and word stress. To this end, the findings from previous research related to Taiwanese English pronunciation problems were taken into consideration in the design of the computer program.

This study aims to examine whether the computer program for pronunciation instruction enhances undergraduate students' pronunciation skills. The computer program for pronunciation instruction was the main experimental instrument of the study to investigate to what extent the undergraduate students can improve their pronunciation. This devised program may help learners distinguish one phoneme from another and make prediction on the placement of stress on a polysyllabic word. It may also offer English teachers a useful tool for pronunciation training in English environment settings. The primary research questions to be addressed in this paper are as follows:

- How effectively can the designed computer program enhance underachievers' pronunciation of English phonemes?
- How effectively can the program improve their pronunciation of English word stress?
- How helpful do the students find it for their English pronunciation improvement?

2. Theoretical frameworks

2.1. Mobile-assisted language learning

With the widespread use of smartphones and tablet PCs, a new concept emerges in relation to the use of technology in language teaching and learning, that is, mobile-assisted language learning (MALL). With the similar idea of integrating technology into language education, MALL offers a great deal of advantages which CALL cannot offer. One of the major aspects that differentiate MALL from CALL is mobility and portability (Kadyte, 2004; Sung, Chang, & Yang, 2015). Mobile devices are easily carried around, making teaching and learning possible in many circumstances. In addition to mobility, the mobile devices provide new experience of interaction between users and machines. Godwin-Jones (2011) asserts, "The responsive touchscreen interface seems to create a more personal, even intimate connection, becoming part of one's personal identity" (p. 8). Furthermore, Stockwell (2010) found that users might utilize "dead time" when commuting via public transportation. The dead time refers to a period of time in which a person can do nothing, for instance, when waiting for a bus. In such circumstances, the person may think spending time studying vocabulary by using a smartphone is better than sitting there and doing nothing. In this case, dead time does not exist because the person has access to a smart phone or tablet PC. To sum up, MALL has already brought about a revolutionary change in how, when and where we learn things, languages in particular.

Due to the fact that mobile and wireless devices are used more and more widely, some scholars have conducted studies, exploring their impact on every aspect of language learning. For instance, Rahimi and Miri (2014) investigated the effect of mobile dictionary use on lower-intermediate language learners. The results of their study showed that the experimental group outperformed the control group in the posttest, suggesting that mobile phones play a crucial role in English teaching and learning. Likewise, Moreno and Vermeulen (2014) developed a mobile-assisted language learning application titled VISP (VIdeos for SPeaking), which uses the technique of audio description to improve the accuracy and fluency of respondents' English speaking. The respondents in their study enjoyed the activities provided in the APP, which can be inferred that MALL has a positive effect on learners' learning motivation. Moreover, the effect of a mobile application focusing on English spelling learning experience was found to be helpful to improve the learners' perception of phonemes and syllables. Furthermore, the learners also built confidence in learning spelling without being afraid of new vocabulary. Shih, Lee and Cheng (2015) concluded by saying "This case study presents a promising future in applying LINE APP, or other similar APPs on a smartphone to ESL learning, for it is not restricted to learning pace, time, and spaces for learners" (p. 2638). As a new tool for language learning and teaching, not only can MALL fit learners' learning needs, but it can also be a complement to CALL.

Nevertheless, it would have been better if a multimedia application had been developed based on language learners' pronunciation characteristics. Accordingly, the present study aims to integrate the use of both CALL and MALL into English pronunciation teaching and learning.

2.2. Phonemes

A phoneme is the smallest unit of sound that distinguishes one word from another (Celce-Murcia, Brinton, & Goodwin, 1996). Basically, phonemes can be divided into two parts, namely vowels and consonants. Yang (2012) examined the English pronunciation characteristics of native speakers of Taiwan Mandarin, who were English-majoring sophomores at the intermediate-level English proficiency. In view of the participants' intermediate-level English proficiency, the findings are considered significant in terms of the English spoken in Taiwan. As opposed to the sound features identified from the participants at intermediate-level English proficiency in Yang's research (2012), other features used by Taiwanese learners of English at the elementary level were found in other studies (Cheng, 1997; Chung, 2006). The phonetic features are listed below in Table 1.

Table 1. Phonetic features of Taiwanese learners' pronunciation

Phonetic feature	Example
Substitution of /d/ for /ð/	*that* → /dæt/
Substitution of /dʒ/ for /ʒ/	*decision* → /dɪsɪdʒən/
Substitution of /l/ for /r/	*right* → *light*
Substitution of /n/ for /m/	*seem* → *seen*
Substitution of /n/ for /ŋ/	*king* → *keen*
Substitution of /s/ for /θ/	*thousand* → /saʊznd/
Insertion in a consonant cluster	*act* → /ækət/
Vowel shift from /æ/ to /ɛ/	*vast* → *vest*
Vowel shift from /e/ to /ɛ/	*table* → /tɛbl/
Vowel shift from /ɪ/ to /i/	*ear* → /ir/
Vowel shift from /o/ to /ɔ/	*low* → *law*
Vowel shift from /ʊ/ to /u/	*put* → /put/
Vowel shift from /ʌ/ to /ɑ/	*color* → *collar*

2.3. Word stress

Liao (2012) addresses the issue of Taiwanese speakers placing wrong stress when pronouncing English polysyllabic words. He suggests that learners can predict the location of the word stress according to lexical suffixes. He explains that Taiwanese speakers of English may use word stress rules to reduce the possibility of misplacing English word stress, as presented in Table 2.

Table 2. Word stress rules

Suffixes	Place of word stress	Examples
-ee or -eer	last syllable	*absentee, addressee*
-ic	last second syllable	*academic, atmospheric*
-ial	last second syllable	*artificial, superficial*
-ion	last second syllable	*abolition, accusation*
-cious or -tious	last second syllable	*capricious, suspicious*
-ical	last third syllable	*biological, metaphorical*
-ity	last third syllable	*ability, accessibility*
-logy	last third syllable	*biology, phonology*

To this end, a computer program for English pronunciation learning was devised based on the phonetic features of Taiwanese learners' pronunciation and word stress rules that could solve the problem of Taiwanese learners misplacing the primary stress on a word. This study was done with the hope that Taiwanese learners of English could have their English pronunciation improved by knowing their pronunciation difficulties first, and then having a knack of making correct pronunciation.

3. Method

3.1. Participants

Thirty-eight participants enrolled in the remedial English class offered at the language center of a technological university in central Taiwan. Fifteen of them were males and twenty-three were females aged from 18 to 35. They were regarded as underachievers in English learning because their scores on the mock TOEIC test ranged from 123.8 to 366.3 (M= 264.1), which placed them at the low-intermediate level. This study examined the English-learning underachievers who had had no frequent contact with native speakers of English and had no experience of living in an English-speaking country for more than three months.

3.2. Instruments

3.2.1. The computer program assessment questionnaire

The computer program assessment questionnaire1 was designed to assess if the participants found the computer program helpful to improve their English pronunciation. It consists of 10 items with each on a 5-point Likert Scale format. Some of the items are concerned with the given instruction, and they were adapted from the questionnaire developed by Atli and Bergil (2012), whose original

1 The computer program assessment questionnaire appears in Appendix A.

Cronback's alpha was 0.84. Some of the items were included to assess the use of the pronunciation program, and they were revised on the basis of the measurement developed by Chavangklang (2013), who aims at surveying the participants' opinions towards the e-learning package used in his study.

3.2.2. A word list for the pretest and posttest

For the purpose of analyzing the participants' phonetic production and identifying the improvement made by the participants, a word list2 regarding phonemes and word stress was developed for the students to read. The word list consists of 120 words and is divided into three sections, thus each section containing 72, 24, and 24 words respectively. The words in sections 1 and 2 are selected from the computer program. The words in section 3 are pseudo-words which were created according to phonotactics to explore how well the participants can apply the given rules to predict the placement of word stress on polysyllabic words. This word list was used in both the pretest and the posttest to examine how the students find the designed computer program helpful to improve their articulation of English vowels, consonants, and word stress.

3.2.3. Open-ended questions

Three open-ended questions3 were set to collect qualitative information (Ballou, 2008). The open-ended questions were used to delve into the participants' pronunciation performance in the acquisition of phonemes and word stress. The responses from the open-ended questions provide helpful suggestions for future research on teaching and learning of English pronunciation.

3.2.4. Design and development of the computer program

A computer program has been designed by the researcher and used as the main experimental instrument in this study. This multimedia pronunciation program aims to help the participants improve their English pronunciation accuracy. The program consists of three parts, namely phonemes, word stress, and more information, as shown in Figure 1.

First of all, phonemes are divided into two parts, vowels and consonants, as presented in Figure 2. In the category of vowels, words are paired according to their similarities, as displayed in Figure 3. In the category of consonants, words are arranged according to the mouth position, as exhibited in Figure 4.

2 The word list appears in Appendix B.

3 The open-ended questions appear in Appendix C.

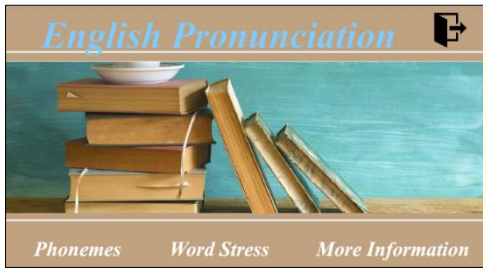

Figure 1. The front page of the computer program

Figure 2. Vowels and consonants

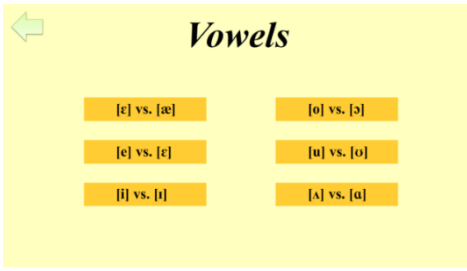

Figure 3. Phonemes in pairs

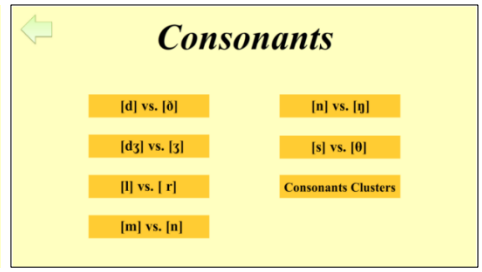

Figure 4. Consonants in pairs according to the mouth position

Furthermore, when it comes to variations in stress related to the grammatical structure, it is possible to predict where the stressed syllable is in most English words (Ladefoged, 2006, p. 111). Hence, the words in the section of word stress are categorized based on their suffixes, as illustrated in Figure 5. This arrangement of the words is based on the book titled *Academic English Oral Presentation* (Liao, 2012), which highlights Taiwanese English pronunciation problems.

Lastly, the computer program also provides more information about English sound features for learners, including linking, intonation and weak syllables, as shown in Figure 6. Although this part was not examined in this study, having sufficient phonetic knowledge is highly required and helpful to English learners. As Herbert (2002, p. 189) asserts, "Learners need to have some understanding of the role phonology plays in language." Therefore, English teachers should not neglect the importance of teaching sound features, both segmental and supra-segmental alike.

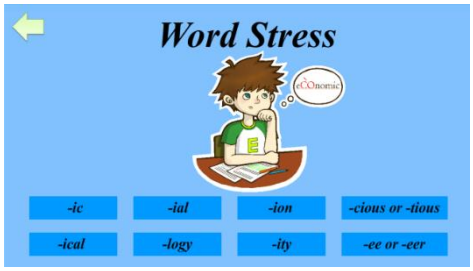

Figure 5. The classification of word stress based on the suffixes

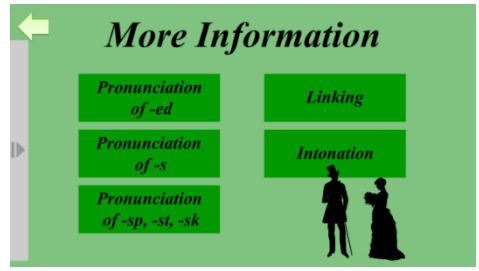

Figure 6. More information about linking, intonation and weak syllables

This computer program provides some examples of words and sentences with clickable sounds, as presented in Figure 7. These sentences were extracted from some online dictionaries, such as *Cambridge Dictionary*, *Macmillan Dictionary*, *Merriam-Webster Online Dictionary*, and *Oxford Dictionaries*. All the audio clips embedded in the computer program were made in American English and later edited using Praat software. In addition, some key points written in both English and Chinese are provided on the program to help learners understand the concepts in point, as displayed in Figure 8 and Figure 9. Additionally, references are listed on the computer program with hyperlinks enabling learners to check out further information, as exhibited in Figure 10.

Figure 7. Examples of words and sentences with clickable sounds

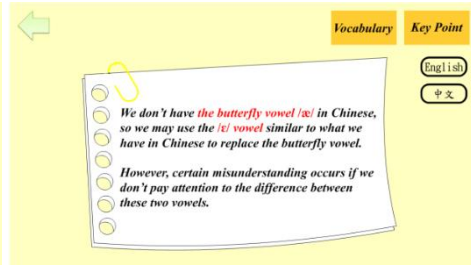

Figure 8. Key points which offer learners necessary concepts

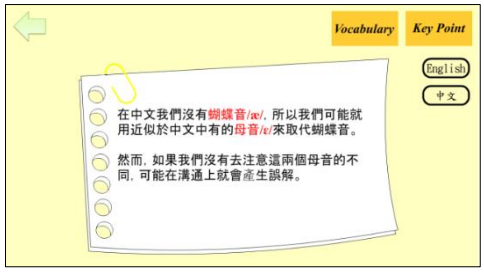

Figure 9. Chinese translation of key points

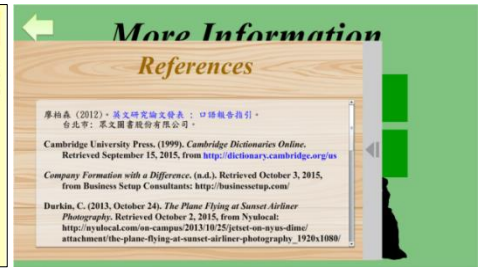

Figure 10. References with the function of hyperlinks

The computer program was designed by means of Flash CS6. To use it, learners were instructed to install it on their desktops or laptops. Given that the software developed on Flash CS6 can be published to the applications for portable devices, learners can also download the designed computer program on their smartphones or tablet PCs, whose operating system is Android.

3.4. Data collection procedures

Each lesson plan is about an hour a week, totaling eight hours for eight weeks. Firstly, a pretest was conducted in the first week before the English pronunciation instruction. The students were asked to read the word list aloud at a normal pace, and their readings of the word list were recorded for sound analysis. They were told not to look up the word they did not know, but to read through the word list based on their existing knowledge.

Secondly, the students began to practice English phonemes and word stress with the designed computer program, together with the researcher's instruction, which is six weeks in length. They were instructed to download the computer program for use on their Windows or Android operating systems. The use of the computer program enabled them to practice after class on their own at their convenience.

Finally, the students were given a posttest after the given instruction. They were required to read the same word list as used in the pretest. Their pre- and post-readings were compared to examine the effects of the lesson plan. Then, the computer program assessment questionnaire was used to explore how helpful the students find the computer program. At the end of the data collection procedures, the open-ended questions were asked to explore their pronunciation performance.

3.5. Data analysis

Eight participants' readings of the test words were transcribed by the researcher for sound analysis. The participants were selected because they only missed one of the six lessons. In addition, the chosen participants all claimed to have English certificates in the elementary or intermediate levels of the GEPT, or have the scores between 350 and 550 on TOEIC. Hence, only eight participants' readings were sifted out by the criterion for the sound analysis of the study.

Regarding the sound analysis, perceptual ambiguity was resolved by acoustic analysis using the sound program, Praat. Next, the researcher discussed his initial transcription with his advisor. Afterwards, the rate of incorrect productions of the participants' pre- and post-readings were compared to examine if any significance exists between the pretest and the posttest.

In the quantitative aspect, the descriptive statistics was used to explain the participants' responses to the computer program assessment questionnaire. In the qualitative aspect, the data collected from the open-ended questions were

examined to gain a deeper understanding of the participants' pronunciation achievements in the acquisition of phonemes and word stress.

4. Results

4.1. Phonemic analysis

The participants' readings of the test words were analyzed to examine whether each pair of phonemes were differentiated in pronunciation. The findings show that in the pretest the vowel /æ/ was mispronounced most often among others. Specifically, it was substituted 83% of the time for /ɛ/ in the pretest, as in *said* for *sad*. In contrast, the average substitution rate in the posttest reduced to 58.3%, declining by 24.7%, indicating the greatest improvement among others. The participants also tended to pronounce /u/ 62.5% of the time for /ʊ/ in the pretest, as in *pool* for *pull*. Nevertheless, the overall substitution rate in the posttest declined to 54.2%, decreasing only by 8.3%, indicating that most of the participants still could not distinguish the difference between /u/ and /ʊ/ sounds. The inaccuracy rates of the vowels are presented as follows, where phonological feature refers to substitution, while complete incorrect productions indicate that the entire words are mispronounced.

Table 3. The inaccuracy rates of the vowels

Occurrence rates / Vowels	Pretest		Posttest		Pretest-Posttest (phonological feature)
	Phonological feature	Complete incorrect productions	Phonological feature	Complete incorrect productions	
/æ/→/ɛ/	83%	0%	58.3%	0%	24.7%
/ɪ/→/i/	37.5%	8.3%	25%	4.2%	12.5%
/ʊ/→/u/	62.5%	0%	54.2%	0%	8.3%

In terms of articulation, the tongue position of the /æ/ vowel is lower than that of the /ɛ/ vowel, so the first formant frequency of the /æ/ vowel should be higher than that of the /ɛ/ vowel. In addition, the /æ/ vowel is more backward than the /ɛ/ vowel; accordingly, the second formant frequency of the /æ/ vowel should be lower than that of the /ɛ/ vowel. In other words, compared with the /ɛ/ vowel, the /æ/ vowel has a higher first and lower second formants, thus forming a narrow space between them. However, this feature cannot be identified in accordance with the sound pattern of the word *rack* articulated by a participant in the pretest, as shown in Figure 11. Instead, the space between the first and second formants for the /ɛ/ vowel for the word *wreck*, as in Figure 12, is almost the same as that for the word *rack*, suggesting that the participant did not distinguish /æ/ from /ɛ/.

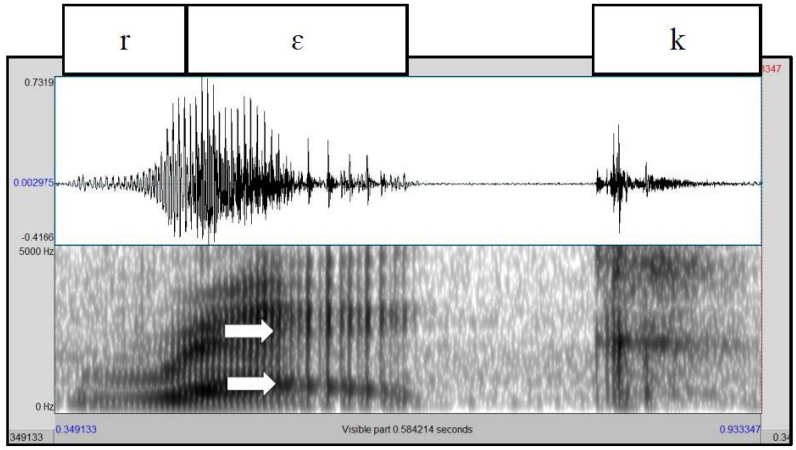

Figure 11. Mis-produced vowel of the word *rack* in the pretest

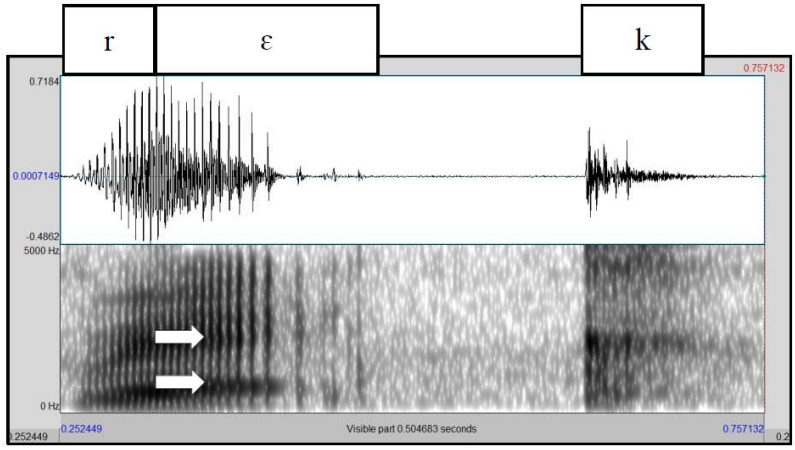

Figure 12. The pronunciation of the word *wreck* in the pretest

Conversely, the participant pronounced the word *rack* much more correctly in the posttest. The first formant appears higher and the second formant frequency appears lower than those in the pretest, revealing that the pronunciation of the vowel approaches the /æ/ vowel rather than the /ɛ/ vowel, as demonstrated in Figure 13. It is also obvious that the first and second formants for the /æ/ vowel are close to each other, making the space narrower, as opposed to the /ɛ/ vowel in the word *wreck*, as depicted in Figure 14.

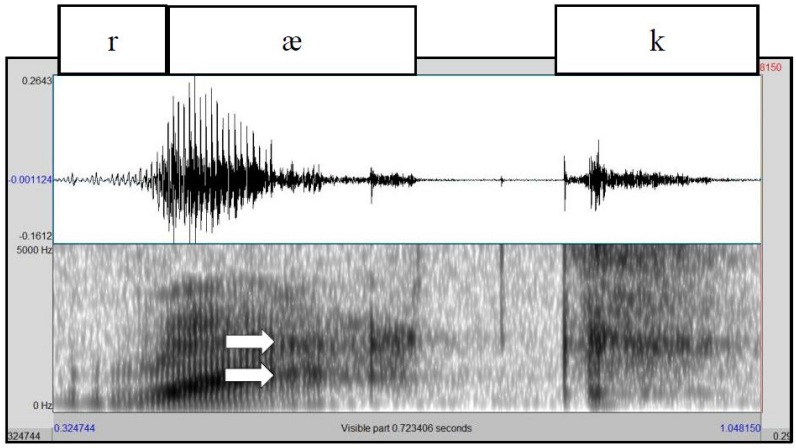

Figure 13. Accurate production of the word *rack* in the posttest

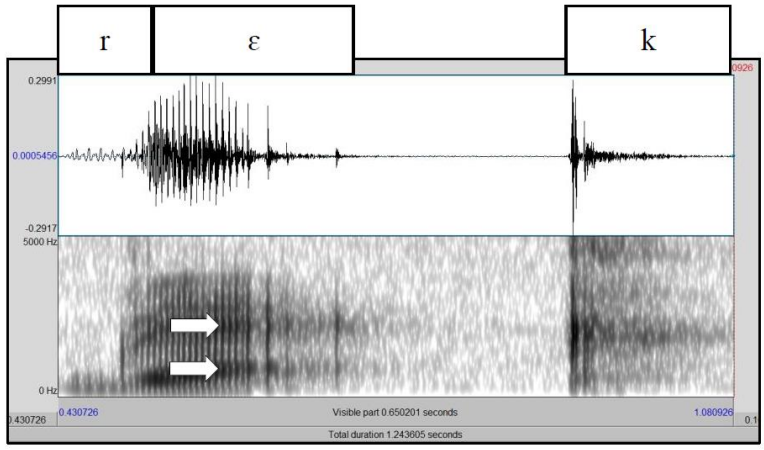

Figure 14. Accurate production of the word *wreck* in the posttest

In the readings of the consonants, the substitution of /dʒ/ for /ʒ/ was identified 58.3% of the time in the pretest, as in *pledger* for *pleasure*, showing that the participants had a strong tendency to use /dʒ/ sound in place of /ʒ/ as in such words as *pleasure*, *measure* and *version*. Nonetheless, the overall replacement rate in the posttest reduced to 41.7%, descending by 16.6%. This finding shows the most significant improvement among all consonants. In contrast, the replacement of /m/ for /n/ was found 12.5% of the time in the pretest, as in *scan* for *scam*. Such substitution was not found at all in the posttest. The detailed findings about the inaccuracy rates of the consonants are presented as below, where phonological feature refers to substitution, while complete incorrect productions indicate that the entire words are mispronounced.

Table 4. The inaccuracy rates of the consonants

Occurrence rates / Consonants	Pretest		Posttest		Pretest-Posttest (Phonological feature)
	Phonological feature	Complete incorrect productions	Phonological feature	Complete incorrect productions	
/ʒ/→/dʒ/	58.3%	0%	41.7%	0%	16.6%
/m/→/n/	12.5%	4.2%	0%	0%	12.5%
/θ/→/s/	25%	4.2%	16.7%	0%	8.3%

An acoustic analysis also confirms the perception of the misread words. For instance, the fricative /ʒ/ in the word *pleasure* was mispronounced as the affricate /dʒ/, which makes the word sound like *pledger*. In the spectrogram, a clear gap was identified between the front vowel /ɛ/ and the observed consonant. This gap represents a complete closure of one's vocal tract before a stop consonant is articulated. Given that an affricate includes the feature of a stop consonant, it is apparent that the participant replaced the fricative /ʒ/ with the affricate /dʒ/. Illustrated in Figure 15 is the sound graph of the participant's mis-production of the word *pleasure* in the pretest, where the rectangle refers to the closure of the consonant /dʒ/. In comparison, Feature 16 demonstrates the pronunciation of the word *pledger* in the pretest, displaying the great resemblance between the spectrograms of the two words *pleasure* and *pledger*.

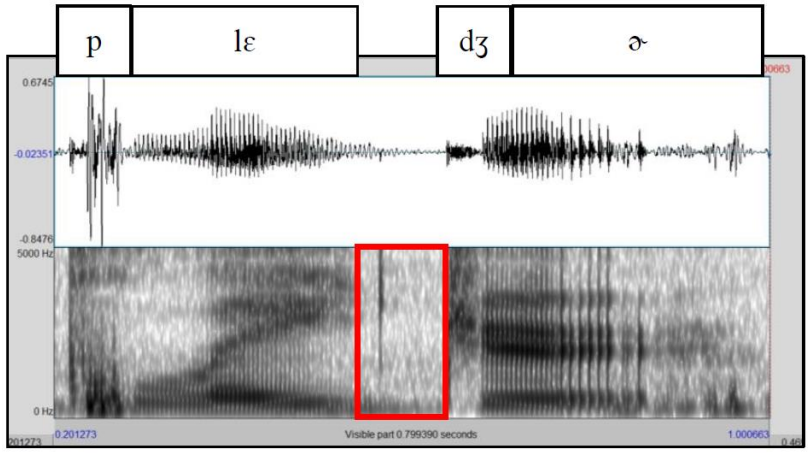

Figure 15. Mis-produced consonant of the word *pleasure* in the pretest

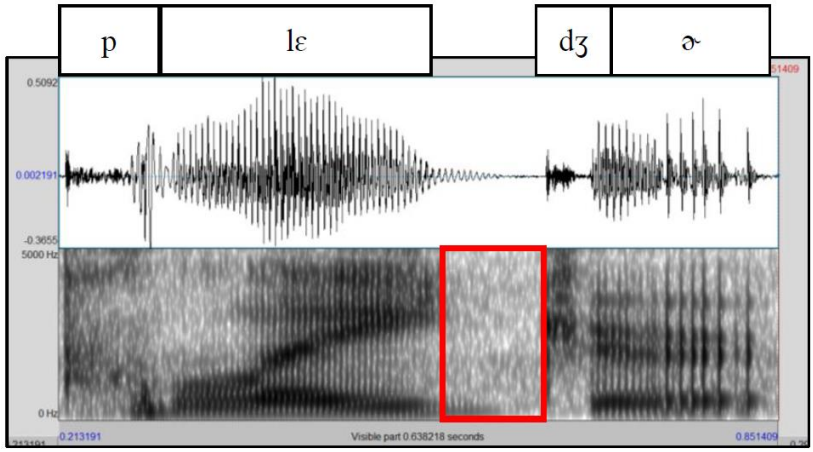

Figure 16. The pronunciation of the word *pledger* in the pretest

In the posttest, the participant correctly pronounced the fricative /ʒ/ in the word *pleasure*. The acoustic analysis shows that a dark pattern, as marked in the rectangle, can be observed, instead of a gap that indicates a complete closure of one's vocal tract before the pronunciation of a stop consonant, as presented in Figure 17. In contrast, Feature 18 illustrates the production of the word *pledger* in the posttest, demonstrating that the participant was able to differentiate the minimal pair after the given instruction.

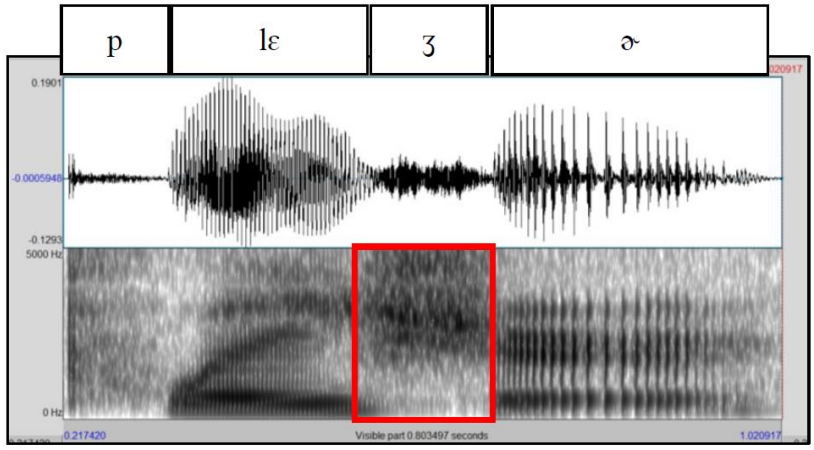

Figure 17. Accurate production of the word *pleasure* in the posttest

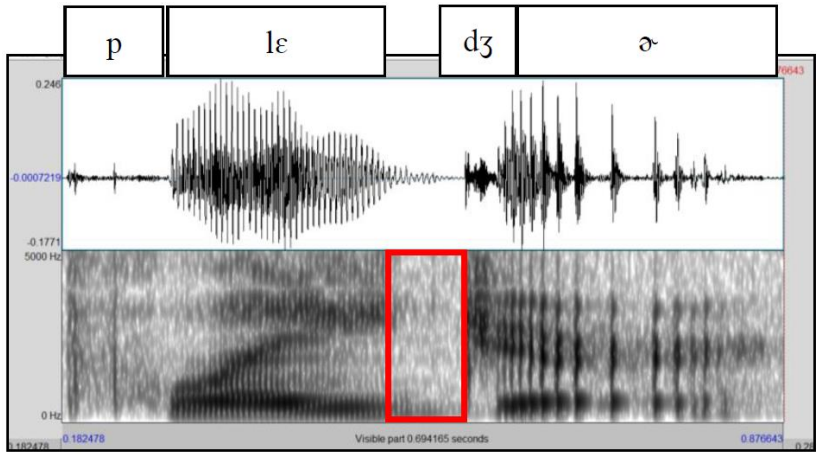

Figure 18. Accurate production of the word *pledger* in the posttest

4.2. Word stress analysis

The participants' readings of the test words regarding word stress were analyzed according to whether syllables were stressed correctly, or the test words were pronounced completely wrongly. The stress of the -ic ending words was located 66.7% of the time incorrectly on other syllables in the pretest, as in *`strategic* for *stra`tegic.* In contrast, the dislocation rate in the posttest lowered to 29.2%, decreasing by 37.5%, revealing that the participants made the greatest improvement in pronouncing -ic ending words. The stress of the words with the -ion suffix was only found to be placed 8.3% of the time incorrectly in the pretest. Nonetheless, this lowest score shows the capability the participants had to pronounce -ion ending words before the given instruction. As for the posttest, its displacement rate declined to 4.2%, with the decrease of 4.1%. The least improvement might be attributed to the lowest score in the pretest. The stress of the words that end with -ity was put 70.8% of the time incorrectly on other syllables in the pretest in words like *po`tentiality* for *potenti`ality*, resulting in the highest score outnumbering others of the pretest. This shows that the participants found it most difficult to pronounce the -ity ending words. For the posttest, the displacement rate declined to 45.8%, diminishing by 25%.

Table 5 illustrates the inaccuracy rates of word stress, where dislocation of word stress refers to misplaced stress, while complete incorrect productions indicate that not only stress but also phonemes are mispronounced.

Table 5. The inaccuracy rates of word stress

Occurrence rates / Suffixes	Pretest		Posttest		Pretest-Posttest (Dislocation of word stress)
	Dislocation of word stress	Complete incorrect productions	Dislocation of word stress	Complete incorrect productions	
-ee or -eer	62.5%	4.2%	45.8%	0%	16.7%
-ic	66.7%	8.3%	29.2%	4.2%	37.5%
-ial	25%	8.3%	8.3%	0%	16.7%
-ion	8.3%	16.7%	4.2%	0%	4.1%
-cious or -tious	16.7%	8.3%	4.2%	4.2%	12.5%
-ical	37.5%	12.5%	25%	0%	12.5%
-ity	70.8%	4.2%	45.8%	4.2%	25%
-logy	16.7%	16.7%	12.5%	4.2%	4.2%

For example, the word *potentiality* is stressed on the last third syllable, while it was mis-stressed on the second syllable by a participant, as in the adjective form *potential*. As a result, the pronunciation of the syllable -tial approximates /ʃəl/. This stress dislocation makes the syllable -tial unidentifiable on the spectrogram because the first and second formants do not stay apart and then get close for the diphthong /ɪæ/. Specifically, the first formant of the vowel /ɪ/ appears not to be low and the second formant appears not to be high enough to display a greater space between the two formants. Instead, the vowel /ə/ is identified in place of the diphthong because both the first and second formants appear at the lower level on the spectrogram. Depicted in Figure 19 is the sound graph of a participant's mis-production of the word *potentiality* in the pretest.

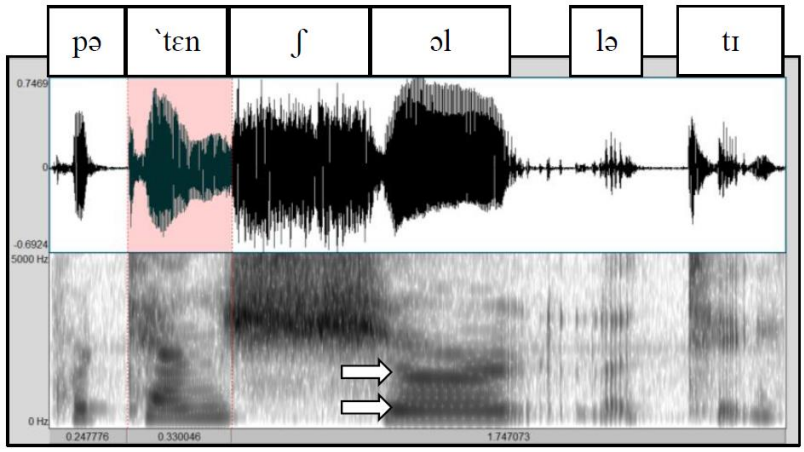

Figure 19. Mis-produced stress of the word *potentiality* in the pretest

Nevertheless, in the posttest, the participant successfully located the primary stress on the correct syllable for the word *potentiality*. Although the first and second formants of the vowel /ɪ/ are not clear due to slight pronunciation made by the participant, it can still be seen the two formants stay apart before entering the marked area where the vowel /æ/ is produced. Acoustically, the second vowel of the syllable -ial is found to approach the vowel /ɑ/ because the second formant of the syllable is low enough to get close to the first formant, as illustrated in Figure 20.

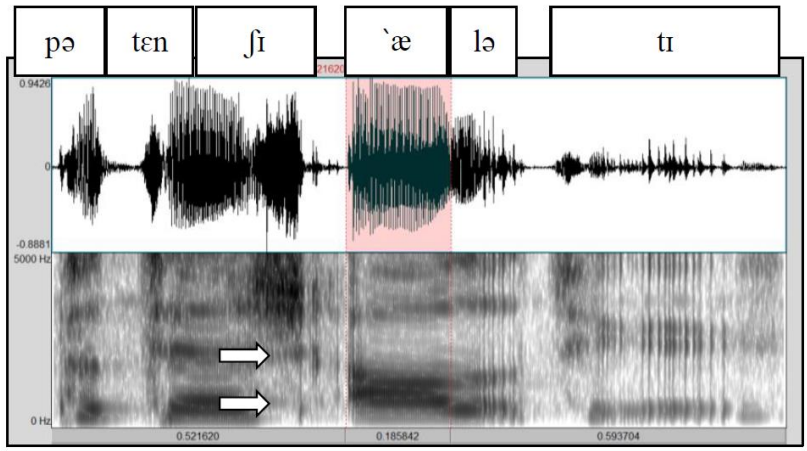

Figure 20. Accurate production of the word *potentiality* in the posttest

To confirm the sound analysis, a speaker of American English was invited to articulate the same word. It was found that the darkest waveform and the largest amplitude occur on the vowel /æ/, suggesting the loudest sound was given to the primary stressed vowel. In addition, in the spectrogram, the front vowel /ɪ/ starts with a higher second formant and proceeds to approach the back vowel /æ/ with a lower second formant. Figure 21 presents the sound graph of the word *potentiality* spoken by the American English speaker.

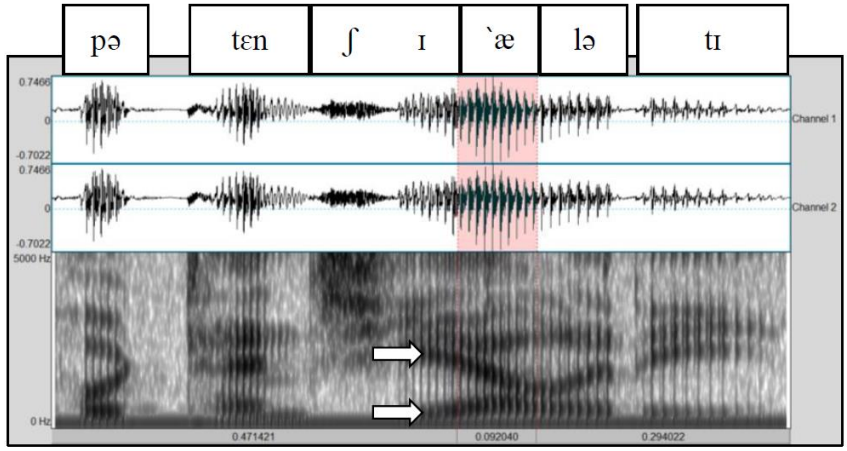

Figure 21. The American spectrogram of the word *potentiality*

As for the inaccuracy rates of the pseudo words, surprisingly, most of the participants failed 91.7% of the time when pronouncing -ee or -eer ending pseudo words in the pretest. In the posttest, the dislocation rate still remains the highest 83.3% of the time among others. These findings indicate that the participants still had difficulty placing the stress on the correct syllable of the -ee or -eer ending pseudo words. In contrast, the stress of the -ion ending pseudo words was only placed 4.2% of the time incorrectly in both the pretest and the posttest, which reveals that most of the participants did not regard pronouncing the -ion ending words as a problem. On average, the differences in the dislocation of word stress between the prettest and the posttest regarding the pseudo words are lower than those in real words, indicating that using the word stress rules for pseudo words is more challenging than real English polysyllabic words. Table 6 demonstrates the inaccuracy rates of the pseudo words.

Table 6. The inaccuracy rates of the pseudo words

Occurrence rates / Suffixes	Pretest		Posttest		Pretest-Posttest (Dislocation of word stress)
	Dislocation of word stress	Complete incorrect productions	Dislocation of word stress	Complete incorrect productions	
-ee or -eer	91.7%	0%	83.3%	0%	8.4%
-ic	54.2%	8.3%	45.8%	0%	8.4%
-ial	58.3%	12.5%	41.7%	4.2%	16.6%
-ion	4.2%	12.5%	4.2%	4.2%	0%
-cious or -tious	12.5%	16.7%	4.2%	20.8%	8.3%
-ical	33.3%	8.3%	25%	4.2%	8.3%

Occurrence rates / Suffixes	Pretest		Posttest		Pretest-Posttest (Dislocation of word stress)
	Dislocation of word stress	Complete incorrect productions	Dislocation of word stress	Complete incorrect productions	
-ity	16.7%	4.2%	12.5%	0%	4.2%
-logy	25%	4.2%	8.3%	4.2%	16.7%

4.3. Results of the computer program assessment questionnaire

The computer program assessment questionnaire which consists of 10 items was analyzed by means of descriptive statistics. The mean scores and standard deviations of each question were calculated. The results of the items 1 to 5 concerning the given instruction show that the participants agreed or strongly agreed with the effectiveness of the given instruction. A great number of the participants thought that they have learned the rules of pronunciation from the course and put these rules into practice (*M*= 4.42, *SD*= .599). The results also indicate that not only did they think this course was helpful to their English pronunciation (*M*= 4.18, *SD*= .692), but they also believed that this course have raised their awareness of the importance of English pronunciation (*M*= 4.37, *SD*= .675). The mean scores and standard deviations of the items concerning the given instruction are displayed in Table 7.

Table 7. The participants' feedback about the given instruction

	Items	*M*	*SD*
1	I think the course is helpful to my English pronunciation.	4.18	.692
2	I think the course helps me become more confident in English use.	3.89	.727
3	I think the course makes me understand the importance of English pronunciation.	4.37	.675
4	I think the course enables me to learn the rules of pronunciation and its application.	4.42	.599
5	I think the course can effectively improve my English pronunciation.	4.13	.741

Note:
M refers to the mean scores.
SD refers to standard deviations of each item regarding the participants' feedback about the given instruction.

Most of the participants reported favorably on the use of the pronunciation program according to the scores from their opinions to items 6 to 10. The highest mean score is found on items 7 (*M*= 4.26, *SD*= .644) and item 10 (*M*= 4.26, *SD*= .828). Besides, both of the items are concerned with the convenience of the pronunciation program for the acquisition of English sound system.

The second highest score was found on item 6, revealing that the participants felt that the structure of the content as well as the function built in the computer program had helped them to learn English pronunciation in a systematic way (*M*=

4.18, *SD*= .692). The mean scores and standard deviations of the items in relation to the use of the pronunciation program are illustrated in Table 8.

Table 8. The participants' opinions about the use of the program

	Items	*M*	*SD*
6	The computer program used in the course enables me to learn English pronunciation systematically.	4.18	.692
7	The computer program used in the course can work on computers and mobile devices, which is convenient to my practicing English pronunciation.	4.26	.644
8	The computer program used in the course helps me improve my speaking skill.	3.97	.716
9	The computer program used in the course is suitable for my ability.	3.89	.798
10	The computer program used in the course allows me to practice at my convenience.	4.26	.828

Note:
M refers to the mean scores.
SD refers to standard deviations of each item regarding the participants' opinions about the use of the program.

4.4. Results of the open-ended questions

The open-ended questions were composed of three questions in regard to the participants' pronunciation achievements and their feedback on the pronunciation program. Each question was shown below, together with the participants' responses.

1. Please explain whether the computer program used in the course helps you learn English phonemes.

A large number of the participants reported that they are capable of distinguishing two similar phonemes after taking the course, as shown in the following extracts:

- *I couldn't distinguish the difference between [n] and [ŋ]. Now, I know they differ in the tongue positions.*
- *This App is really helpful. I knew the difference of [ɛ] and [æ] in the past, but I failed to identify another similar sound [e], which resulted in pronunciation difficulty. Moreover, I can use the App to listen to the imbedded pronunciation and practice with it whenever and wherever I want. In addition, thanks to this App, I finally understand the difference between [m] and [n].*

2. Please explain whether the computer program used in the course helps you learn English word stress.

Surprisingly, some students stated that they had very little knowledge of word stress, while others commented that they have built up certain understanding to the word stress, and with the rules of word stress, they would try to read polysyllabic words when reading English articles, as illustrated below:

- *Not until I used this App did I know what word stress is. I probably knew how to read a polysyllabic word, but I was not so sure about the position of the stress for that word. With this App, it is easier to know how to read a long word, such as the word "characteristic".*
- *When I encountered a very long word, I would stop doing the reading immediately, and seek for the help from teachers. Without the aid of teachers, I might just give up. Nevertheless, understanding the rules of word stress, I am willing to try to pronounce words that would be difficult for me to pronounce. As a result, knowing the rules of word stress seems to make pronunciation learning easier.*

3. About the computer program used in the course, what are your suggestions for the improvement of the computer program to help learners learn English phonemes and word stress?

Quite a few students pointed out that the sound quality of the American speaker's speech was not satisfactory. Some said that the speech rate of the American speaker could be slower. Others brought up some great ideas for the further improvement of the pronunciation program, as presented below:

- *There are some noises in this app. Better equipment is advised.*
- *The pronunciation of the built-in readings would be clearer if the speed of the way the American speaks could go more slowly.*
- *Maybe some functions can be built in, such as the rate of progress for everyday practice. By doing so, users can be motivated to use the App more often.*

5. Discussions and conclusions

This study has shown that the integration of the devised computer program in the instruction can enhance underachievers' acquisition of English phonemes and word stress. Although the /æ/ vowel troubled most of the students in the beginning, they have learned to distinguish this vowel from the /ɛ/ vowel. They also tended to pronounce the consonant /ʒ/ as /dʒ/ at first, but eventually were capable of differentiating the two consonants. They have come to realize that the mouth position affects ways of articulation, indicating that they have acquired the essential knowledge of English phonetics.

The word stress analysis also indicates that the MALL-driven instruction has a positive impact on the learners' acquisition of English phonology, as shown in the participants' considerable improvement in -ity ending words like *potentiality* and *authenticity*. In particular, they have made the greatest progress in the -ic ending words, such as *economic* and *academic*. They also commented in the questionnaire and open-ended questions that they would try to predict the stress of polysyllabic words using the rules of word stress that they learned from the given instruction and the computer program.

The present findings contribute to the field of MALL-based English pronunciation teaching and learning. Firstly, the participants in the present study have acquired important knowledge of English pronunciation in terms of phonemes and word stress. These findings can infer that EFL learners have learned to distinguish one phoneme from another and place the primary stress on a correct syllable. Secondly, some of the participants' answers to the open-ended questions were unexpected. For instance, they claimed that not until they took the course did they know what word stress means. This feedback points out the lack of emphasis on pronunciation teaching and learning in their past English classes. For this reason, it is essential for English teachers to pay much attention to the importance of English pronunciation teaching. Thirdly, the structure arranged in the devised program could facilitate the participants' English pronunciation acquisition. The contents in the devised computer program were based on the findings on Taiwanese learners' pronunciation characteristics and the book titled *Academic English Oral Presentation* (Liao, 2012), which discusses Taiwanese learners' pronunciation difficulties. As a result, learners can regard this program as an alternative tool for the improvement of their English pronunciation, and teachers can make good use of the designed computer program in English teaching. To sum up, it is hoped that the present study can shed some light on the issue of pronunciation teaching and pave the way for further research projects which integrate MALL into English pronunciation instruction.

Some difficulties were encountered in the process of conducting the study. First, the quality of the sounds in the computer program recorded by a native speaker of American English is not satisfactory because a slight noise appears at the beginning and end of a sentence. Accordingly, it would be better if a professional recording microphone was used for the recordings. Furthermore, only 8 out of 38 recordings were used for data analysis because of unclear audios made by the majority of the participants. Follow-up research might recruit more participants to better understand the effect of MALL on the acquisition of English phonetics and phonology.

In this study, only English phonemes and word stress were examined, but other aspects of English sound patterns such as linking and intonation are also equally important to improve students' speaking skills. In this regard, an APP can be developed to help students to review and practice different ways of speaking English. Secondly, visual aids can be incorporated into the design of a mobile-based pronunciation program. It would be helpful to include pictures or videos

demonstrating mouth positions in articulation. Thirdly, in addition to test words for data collection, sentences and paragraphs might be included to better understand students' knowledge of English pronunciation. In sum, future research may include visual displays and sentence patterns for a more effective MALL learning.

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Appendix A
The Computer Program Assessment Questionnaire

英語發音軟體使用問卷調查

各位同學您好:

首先非常感謝您撥空參與本問卷的調查。本問卷目的在於了解英語學習者使用此英語發音軟體的使用心得。

本問卷將僅需耽誤您約 10 分鐘的時間，請根據您的先備知識作答即可。
本問卷的內容絕不對外公開，問卷結果僅供學術研究使用。再一次感謝您的協助。

敬祝　事事順心

國立雲林科技大學 應用外語系碩士班
研究生: 洪肇男敬上
指導教授: 楊孝慈博士

整體而言這軟體對於我的英語發音學習

此部分在了解您在經過此發音課程的學習後，對於此課程的看法，請在您認為最適當的□打✓

No.	Item	非常不同意	不同意	無意見	同意	非常同意
1	我認為此課程對於我的英語發音有很大的幫助。 I think the course is helpful to my English pronunciation.	□	□	□	□	□
2	我認為此課程讓我在英語的使用上更有自信。 I think the course helps me become more confident in English use.	□	□	□	□	□
3	我認為此課程讓我了解英語發音的重要。 I think the course makes me understand the importance of English pronunciation.	□	□	□	□	□
4	我認為此課程讓我學習到英語發音的規則與應用。 I think the course enables me to learn the rules of pronunciation and its application.	□	□	□	□	□

5	我認為此課程能有效的改善我的英語發音。 I think the course can effectively improve my English pronunciation.	□	□	□	□	□
此部分在了解您在經過此發音課程的學習後，對於此英語發音軟體的看法，請在您認為最適當的□打✓						
6	此課程的軟體讓我能有系統的學習正確的英語發音。 The computer program used in the course enables me to learn English pronunciation systematically.	□	□	□	□	□
7	此課程的軟體可以在電腦和行動裝置上執行，對我的發音練習十分方便。 The computer program used in the course can work on computers and mobile devices, which is convenient to my practicing English pronunciation.	□	□	□	□	□
8	此課程的軟體能有效改善我的口語能力。 The computer program used in the course helps me improve my speaking skill.	□	□	□	□	□
9	此課程的軟體適用於我的程度。 The computer program used in the course is suitable for my ability.	□	□	□	□	□
10	此課程的軟體讓我隨時隨地都能練習發音。 The computer program used in the course allows me to practice at my convenience.	□	□	□	□	□

【問卷到此結束，感謝您的協助】

Appendix B
English Pronunciation: Word List

Please read the following given words CLEARLY and ALOUD at a NORMAL pace and have your voice recorded with an audio recorder. Please save the file and name it with this format: M10******-**王大明**.wav
請同學以正常的速度大聲的將這些單字念出來，並將您的聲音用錄音機記錄下來。
請將檔案儲存並將您的檔案命名為此格式: M10******-**王大明**.wav

Section 1

1	collect	21	lead	41	correct	61	pray
2	sit	22	then	42	vest	62	pleasure
3	dough	23	fool	43	measure	63	seat

4	sad	24	wet	44	pledger	64	full
5	scan	25	flaw	45	they	65	coat
6	though	26	scam	46	play	66	den
7	look	27	collar	47	wreck	67	coast
8	caught	28	version	48	virgin	68	major
9	sum	29	phone	49	hut	69	color
10	hot	30	vast	50	said	70	live
11	rack	31	read	51	pitch	71	day
12	buddy	32	cost	52	foam	72	flow
13	sin	33	sun	53	sing		
14	tongue	34	wait	54	ton		
15	mass	35	pool	55	kin		
16	taste	36	body	56	leave		
17	pepper	37	Luke	57	paper		
18	king	38	tenth	58	pull		
19	tense	39	math	59	sink		
20	think	40	test	60	peach		

Section 2:
The following words are polysyllable words. Please pay attention to the position of the word stress when you read them.
此部分為多音節單字，請同學在朗誦時，特別留意單字的重音位子。

73	theoretical	79	hypothetical	85	potentiality	91	distribution
74	generosity	80	interviewee	86	pretentious	92	repetitious
75	academic	81	infectious	87	political	93	optimistic
76	evacuee	82	terminology	88	volunteer	94	psychology
77	authenticity	83	strategic	89	substantial	95	confidential
78	negotiation	84	typology	90	inferential	96	recommendation

Section 3:
The following words are fake words (pseudo-words). Please pay attention to the position of the word stress when you read them.
此部分為假字(不存在的字)，請同學在朗誦時，特別留意單字的重音位子。

97	galipial	103	palitegic	109	crosacious	115	jerlition
98	rofality	104	disabation	110	premolisee	116	phonlotious
99	losatical	105	bomosogical	111	cabrecious	117	pafirantial
100	brevamatee	106	versoleer	112	fouligic	118	lofernical
101	mokabial	107	permology	113	sopication	119	crosefology
102	fomalogy	108	tromolity	114	batenpality	120	lakosic

Appendix C
Open-ended Questions

1. 請問此課程中所使用的軟體有幫助你學習英語的母音與子音嗎？請舉例說明。
   Please explain whether the computer program used in the course helps you learn English phonemes.

2. 請問此課程中所使用的軟體有幫助你學習英語單字的重音?請舉例說明。
   Please explain whether the computer program used in the course helps you learn English word stress.

3. 關於此課程中所使用的軟體，請問你有什麼建議可以做為日後改善，以有效協助同學增進英語子母音和重音的學習?
   About the computer program used in the course, what are your suggestions for the improvement of the computer program to help learners learn English phonemes and word stress?

Note: The open-ended questions were given to the participants in both Chinese and English.